

# **DRYING OF STICKY MATERIALS- RELEVANCE TO GLASS TRANSITION TEMPERATURE ( $T_g$ )**

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## **Stickiness issues:**

- **Stickiness on the drier wall (spray drying)**
- **Wet and plastic appearance**
- **Agglomeration and clumping in packing container**
- **Operational problems**

# **Products exhibiting stickiness**

**Products with high amount of sugars or organic acids**

- **Fruit juices/pieces/purees/leathers**
- **Honey**
- **Molasses**
- **Whey (acid or sweet)**
- **High DE maltodextrins (DE>30)**
- **Pure sugars- lactose, glucose, sucrose, fructose**
- **High acid foods**

**High fat foods**

## **Major factors causing stickiness**

- **High hygroscopicity**
- **High solubility**
- **Low melting point temperature**
- **Low glass transition temperature  
(related to thermoplasticity)**

# **Glass Transition Approach**

- **Recent approach to describe stickiness**
- **Applied to spray drying**

## Physical properties of sugars and stickiness behaviour

Sugars	Hygroscopicity (relative)	Melting point (°C)	Approx solubility in H <sub>2</sub> O 60°C (%w/w)	Tg (°C)	Stickiness (relative)
Lactose	+	223	35	101	+
Maltose	++	165	52	87	++
Sucrose	+++	186	71	62	+++
Glucose	+++++	146	72	31	+++++
Fructose	++++++	105	89	5	++++++

# **What is a glass transition?**

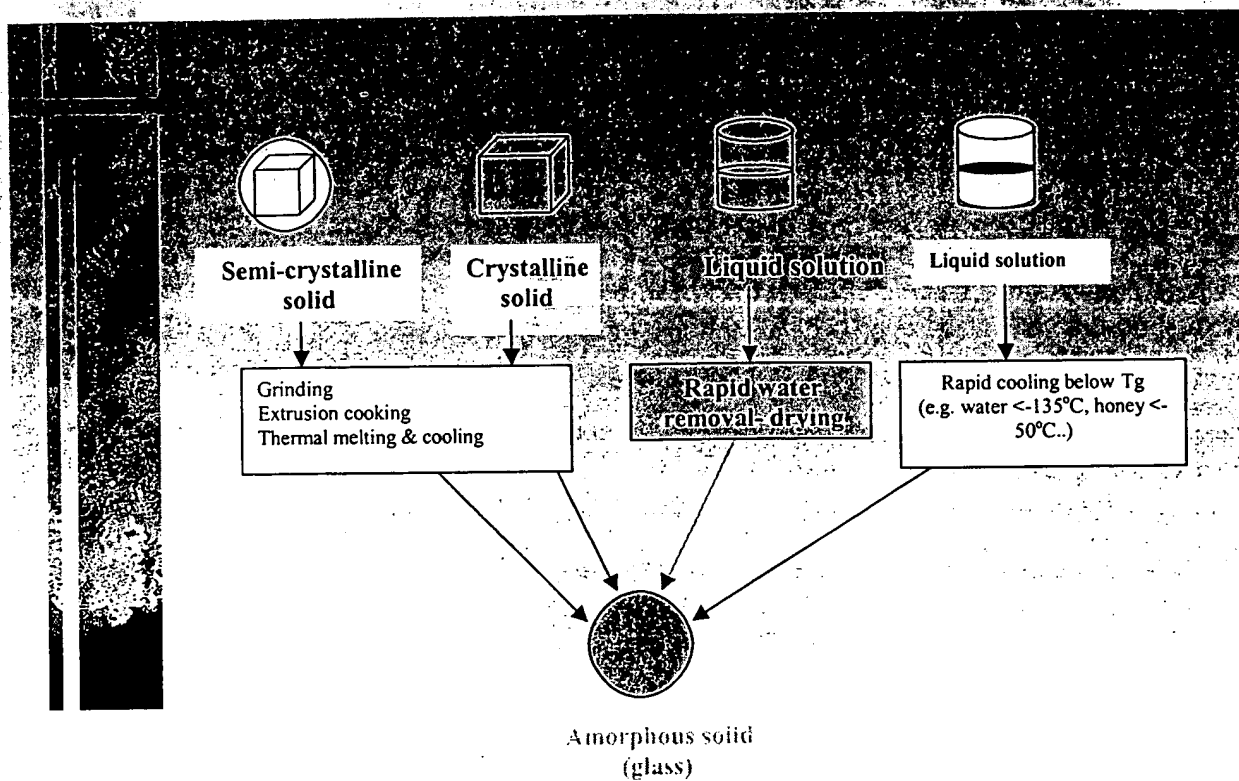
**Physical states of dried or drying solid materials:**

## **— Amorphous**

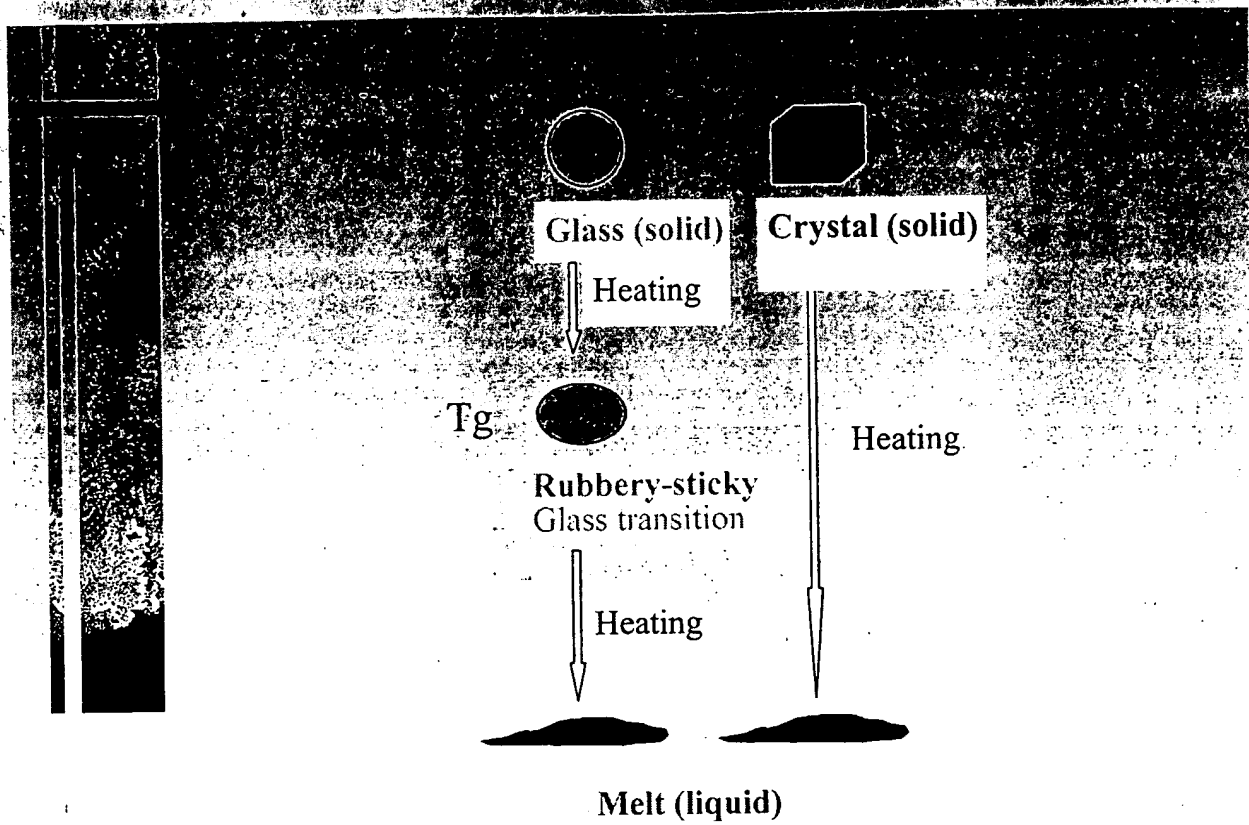
- **non-aligned molecular structure**
- **very hygroscopic**
- **go through glass transition**
- **predominant in dried food**

## **— Crystalline**

- **aligned molecular structure**
- **non hygroscopic**
- **no glass transition**







## **General concepts**

- If the product temperature is above its glass transition temperature ( $T_g$ )- it will exhibit stickiness
- Shorter chain molecules- low glass transition temperature ( $T_g$  of monosaccharides  $<$   $T_g$  of disaccharides)
- Water depresses the  $T_g$  significantly ( $T_g$  of amorphous solid water is  $-135^\circ\text{C}$ )
- For a complex food system, the  $T_g$  is a function of weight fraction of each component and their  $T_g$ 's- but the relationship is not linear

# Glass transition temperature of various food materials

Food materials	$T_g$ (°C) <sup>abc</sup>
Fructose	5
Glucose	31
Galactose	32
Sucrose	62
Maltose	87
Lactose	101
Citric acid	6
Tartaric acid	18
Malic acid	-21
Lactic acid	-60
Maltodextrins	
DE <sup>d</sup> 36 (MW=550)	100
DE 25 (MW=720)	121
DE 20 (MW=900)	141
DE 10 (MW=1800)	160
DE 5 (MW=3600)	188
Starch	243 <sup>e</sup>
Ice-cream <sup>f</sup>	-34.3
Honey <sup>g</sup>	-42 to -51

## Glass transition related problems in various drying processes

• **Spray drying:** sticking on the drier wall, duct and cyclone, poor recovery of powder, agglomeration in the collection bag or container

• **Freeze drying:** "Collapse" of structure while drying

• **Conventional hot air solid drying:** poor fluidisation, stick on the drying racks/shelves, soft product while drying but solid after cooling

• **Storage:** Clumping, agglomeration, caking, crystallisation

## **Some solutions**

- **Drying below the glass transition temperature (often not feasible)**
- **Choosing mild drying temperature conditions**
- **Increasing the Tg of the food by adding high molecular weight materials (such as maltodextrins)- a predictive approach according to the composition**
- **Immediate cooling of the product below its Tg**
- **Appropriate drier design to suit the sticky product**

## **Conclusion**

- **At the glass transition temperature the amorphous food is converted to rubbery state (from its solid glassy state)**
- **If the temperature of the product is above its glass transition temperature it exhibits stickiness**
- **The stickiness can be minimised by lowering drying temperature and increasing the Tg by adding high molecular weight additive**
- **An optimisation procedure is needed to control the Tg of the product and to select correct drying conditions**

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